

Reference SLE Didactics Framework proposal for Moroccan Middle School Teachers: Immunology as a Model

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Abstract—Immunology, by the nature of its concept, is of considerable benefit for the translation of the objectives of health education and teaching of sciences of life and earth (SLE) namely, the formation of the scientific mind and the development of a scientific culture for the student. It is from this angle that a course in immunology has acquired its citizenship right in the Moroccan curriculum of the SLE of the 3rd year of middle school education. Having experienced a scientific revolution, immunology raises several didactic problems for teachers. Continuing training in SLE didactics applied to immunology could be considered as a tool for the professionalization of the teaching act. In this article, we propose a reference framework for SLE didactics modeled on immunology to be integrated into the continuous training of teachers. This framework includes a body of knowledge on various aspects related to the didactics of immunology. These include the historical-epistemological development of immunology, its status in the curriculum and representations of Moroccan students on the concept of immunity.

Keywords —Health Education, Teacher Education, Immunity, History of Science, Representations, Epistemological Barriers.

1 Introduction

Health education should be, today more than ever, one of the major concerns of educational and health institutions. Indeed, with the high cost of care for the state and individuals and the crisis of social security organizations, health has become increasingly a matter of choice and conscious responsibility. The teacher, through health education, aims primarily at empowering students by encouraging them to explore their own attitudes and opinions, to clarify their values and those of others, to analyze the various stages of the decision-making process in relation to health.

Immunology, by the nature of its body of knowledge, makes a considerable contribution to the translation of the goals of health education [1]. Indeed, the teaching of immunology allows the student to acquire cognitive, methodological and affective tools to prevent infectious diseases including the toughest: AIDS. It also

offers him a supply of essential knowledge to understand the institutional, ethical and clinical rules relating to vaccinations, organ harvesting and blood transfusion.

In addition to the relevance of an immunology course in achieving the objectives of health education, it is a major contribution to the achievement of the other objectives of sciences of life and earth (SLE) teaching: the formation of the scientific spirit and the development of a scientific culture for the student.

In this context, with the considerable growth that has recently occurred in immunology as an essential scientific field dealing with the most difficult medical problems (cancer, AIDS, organ transplantation, infectious diseases, autoimmune diseases, etc.), as well as the use of immune-blotting techniques in a larger number of medical tests, immunology has gained an important place in the general scientific culture.

It is from this angle that a course in immunology acquired its right of being a part of the Moroccan curriculum of the SLE of the 3rd year of middle school education with the redesign of the curricula of this cycle launched in 2003-2004 and completed in 2005-2006 [2].

However, a content, as relevant and enriching as it is, does not make it possible to achieve the aforementioned objectives if it is not invested by an appropriate teaching-learning strategy that takes into account several didactical variables, among others, the knowledge and the subject learner. However, the teacher who is supposed to be the mediator and the facilitator of learning would be unable to conceive an appropriate didactic environment [3] to induce optimal and meaningful learning in immunology for the student; because of the lack of consideration of these variables. Nevertheless, in a context of universitarization which now marks the training of teachers in Morocco, the majority of SLE teachers who are currently performing their duties do not have courses in immunology didactics in their university curricula [4].

At this level, continuing training in didactics applied to the teaching-learning of immunology could be considered as a tool entirely dedicated to the professionalization of the pedagogical-didactic acts of these teachers. This will undoubtedly contribute to the development of their professional skills and will enable them to enrich and update their reference framework with regard to didactic procedures and the immunological content to be taught.

This framework includes a body of knowledge on different aspects of SLE didactics related to immunology. These include the historical-epistemological development of immunology, its status in the curriculum and representations of Moroccan students on some concepts of immunology.

Aware of these shortcomings in the training of SLE teachers, we are interested, in the context of this article, in proposing a reference framework for continuing training in didactical SLE of Moroccan middle school teachers: immunology as model [5].

2 Historical-epistemological overview of immunology

Given the well-recognized use of the history of science in didactics [6], the historical-epistemological analysis of immunology seems to be a determining

dimension in the development of a reference framework for continuing training in SLE didactics, immunology as a model. It is relevant in the conception of teaching situations in immunology and in the making of innovative practices related to this teaching [7]. It is also an appropriate framework to categorize student representations related to this field of knowledge. In other words, the historical-epistemological analysis of immunology is indispensable, on the one hand, in the diagnostic research of the students' learning difficulties and, on the other hand, in the conception of a didactic environment appropriate for managing and overcoming these difficulties.

It is a question of examining the historical construction of immunology to see how the scientific *connaissance* is constructed, what obstacles have been overcome, the ruptures and the revolutions envisaged. This historical analysis is based on several models of the history of science, namely the notion of epistemological obstacle and epistemological rupture of Bachelard [8], of scientific revolutions and Kuhn's paradigms [9], of the "pending concept" of Canguilhem [10].

2.1 The Pasteurian model of the disease

This is a conception that does not envisage a clear definition of immunity [11]. In this schema of thought, the disease is essentially assimilated to the exogenous, which is generally represented by a substantial entity that has a huge destructive power. Indeed, the host is represented as a passive entity, innocent and unable to resist the invader who subjected him to its destructive action [12]. In such a representation of the disease, the role of the physician is paramount to restore the initial state of health. It is a person who takes care of the protection of the passive body, deprived of any weapon and subjected to the destructive actions of an exogenous factor. The care envisaged consists in extracting the evil corpus, eradicating it and purifying the body. It is therefore clear that no explicit definition of immunity is envisaged.

2.2 The military-warrior model

Immunity is conceived as a warrior activity that consists of monitoring body integrity against maleficent invaders. The immune system is represented by an army of heroic soldiers who watch and fight against the aggressors [13]. The defense model is represented by two categories: the phagocytic model and the humoral model [14].

2.3 The Lamarckian model

The organism is conceived as a passive entity subject to the conditions of the environment, which imparts to it transformations that are transmitted to the descendants [15]. The immune system is able to respond to an infinite variety of different situations by reacting each time with a specific response. This is a result that automatically leads to the following conclusion: it was necessary to admit that the antigen acts as a matrix or a mould, it is the antigen that "instructs" or "informs" the antibody. This is the fundament of instructive theories that sought to elucidate a valid and convincing mechanism explaining the diversity and specificity of antibodies.

They corroborate the lamarckian belief in an inexhaustible plasticity and adaptability of the living being to its environment [16].

2.4 The Darwinian model

It is a model that considers that in the organism a selection of preexisting recognition structures takes place [17]. The selective theory of immunity constitutes the type of theories, which account for the two essential facts of the vaccine phenomenon: the specificity and the memory. It stipulated that cells spontaneously produce as many different antibodies as they can encounter foreign substances.

2.5 The complexity model

It is a model where the innate and the acquired are taken in a dialectical process where the living being is capable of self-organization and self-formation in interaction with its environment in a goal of integration of the noise, autonomy and production of the new meaning. It attributes to the immune system an adaptive living component with historicity and memory [18].

This system is challenged to solve an internal contradiction, that of responding to the invasion of a foreign element in order to reject it and that of tolerating and sparing everything that belongs to the organism, the "self". This tolerance is no longer conceived as the effect of an ignorance of the self-antigens, but as the result of their active recognition by the organism [19].

3 The status of immunology in the curriculum of the SLE at the Moroccan middle school

3.1 In the programs

In the white book - The time frame reserved for teaching the chapter on immunology is 16 hours. This chapter consists of the following sections [2]:

- The microbes;
- Specific immunity and natural immunity;
- The study of some disturbances of the immune response: allergy and AIDS;
- Some immune problems (blood transfusion and organ transplants).

In text books - With both the privatization (release) and diversification of the textbook publishing sector [20], two textbooks of SLE in the 3rd year of middle school are accredited and institutionalized in the Moroccan middle school 1.

¹ The two accredited textbooks are:
Lamaamer, M. (Coordinator). (2005). Welcome to the sciences of life and earth. The 3rd year of middle school. The new peace bookstore. Casablanca. Morocco.

Admittedly, the importance of the textbook in a teaching-learning situation is very justifiable even though the teacher remains the monitor of scientific knowledge. It is an indispensable tool for learning as it presents itself as a mediator between the scientific community and the learners. As a result, it should demonstrate good management of scientific learning in immunology that must be adequate, relevant and appropriate for the student. The immunology content of both textbooks focuses primarily on immunity as being exclusively a fight against pathogens. It is a defense of the body against the aggressions of the microorganisms of the external environment. Such a representation advocates enough immunity-event that reactivates only on the occasion of the introduction of a foreign body called "antigen". A similar representation hinders the appropriation of an adequate immunology whose essential problem is the recognition and the discrimination of the "self" and the "non self" [14].

In this logic, the chapter on immunology in these manuals includes a section dedicated to microbiology which consists in studying the characteristics of microorganisms and their classification. Now, immunology has been defined as an autonomous science only when it has freed itself from the supervision of microbiology. Indeed, its history is very much related to prophylaxis and antimicrobial control; but the fact remains that this belonging has been behind its stagnation.

In the same vein, the presentation of the immune response, triggered by an allergy or an incompatible organ transplant, will have no meaning for the student. It will not be integrated into its cognitive structure since it contradicts his/her beliefs and evidences. The student sees allergens or grafted tissues as harmless bodies compared to bacteria, which are presented to him as harmful, dangerous and aggressive bodies that must be combated.

Admittedly, the military-warrior model of immunity is a very important model for circumventing it in a single teaching-learning situation. School textbooks are then invited to consider several constraining situations in order to be able to reach a conceptual complexification, to induce a conceptual change in the student. These binding situations could be: autoimmune diseases, allergy, Rh incompatibility between the mother and the fetus, etc..

In addition, the warlike conception does not make it possible to highlight the other side of immunity, namely tolerance; which implies that all mechanisms enable the organism not to react against its own constituents. It presents itself as an obstacle difficult to overcome so that the learner appropriately appropriates the mechanisms of tolerance: a set of molecules specific to the individual constituting its immunological identity.

The two textbooks, while being consistent with this relatively reductionist conception, the warlike conception, present the hard core of the current immunology, that is to say the mechanisms of distinction of self and non self and the supports of the biological identity as ancillary problems. They link them to the issues raised by blood transfusion and organ transplants without indicating the involvement of blood groups in the determination of biological identity.

Faiz, T. (Coordinator). (2005). The clear in sciences of the life and the earth. The 3rd year of middle school. Modern House of Rashad. Casablanca. Morocco.

The immune-deficiencies presented by textbooks that are limited to AIDS and allergies have not been studied in a perspective that allows a rectification of the reductionist conception of a defense-oriented immune system. AIDS has revolutionized the conceptual field of immunology by putting into disuse a simplistic and linear conception of immunology related exclusively to prophylaxis and the fight against infectious diseases.

The study of allergies has also raised the debate on the purpose of the immune system which is no longer confined to protecting the body against the aggressors. Allergies encourage the conception of the immune system as a homeostatic system that maintains dynamic relationships between the human body and the environment to safeguard a certain harmony between these two entities.

The two textbooks therefore present immunology in a way that does not facilitate learning, because they do not take into account the student's representations of the different immunological notions or the profound changes that have taken place in this discipline.

3.2 The difficulties inherent in the teaching of immunology

The philosophical language - Immunology presents itself as a prime example where one can perceive the philosophical and the ideological in Science. Indeed, it is hardly conceivable to remain indifferent to ideological connotations - rejection, tolerance, integrity, individuality, identity, surveillance... etc [21] – that the vocabulary of immunology carries.

Although these concepts, certainly metaphorical in nature, are explicitly defined in their field of validity delimited by immunology, their sliding and migration into other fields, other than biology, can be behind harmful distortions [22]. The semantic field of these terms thus encourages a particular mistrust on the part of the teacher.

Immunology and everyday life - The discourse in immunology conveys a number of notions that are common in everyday life. Students are relatively familiar with this discourse from an early age (vaccination, epidemic, microbe, blood transfusion ... etc.). Now, the familiarity of a notion is not synonymous with its limpidity [21]. Indeed, in the students' learning experience, there are images, myths and thought patterns derived from social practices with a set of overestimation and over-determination which stand behind certain types of conceptual difficulties [23].

Immunology and popular science - With the emergence of AIDS in the spotlight, the media coverage of the immune system has grown considerably. However, the mass media report spectacular, even fanciful information that is essentially based on wonder, attraction and seduction to the detriment of structured, thoughtful, refined and well-targeted data. In short, it is a popular science whose basic principle is "the showcase effect" [24]. Indeed, several television programs or popular articles are designed to show citizens the wonders that scientists are capable of producing. They claim to explain what researchers do to lay people who do not understand anything. Generally, learners are often attracted by this type of popularization. This mediated universe more or less structures the students' frame of reference and their reception

system and can constitute an obstacle to the appropriation of adequate, relevant and appropriate knowledge in immunology.

A first identification by flipping through popularization texts in immunology allows us to draw up a sorting out or inventory of inappropriate illustrations. The immune system is often represented by a "police" or an "army of watchmen". They show the immune system as a repressive body that monitors, through heroic defenders, bodily integrity against evil aggressors. Analogies, often used, draw their meaning from a very homogeneous register: the warrior register [25]. The immune system is compared to an army, immune cells to soldiers, antibodies to lethal weapons and chemical mediators to destructive substances.

Therefore, the teacher, whose task becomes more and more difficult due to these multiple sources of information, is called more than before to sort out students and provide them with a coherent and structured scientific knowledge.

Learner representations are structures that underlie a process of building knowledge. This concept already constitutes the frame of reference from which the integration of the new knowledge is proposed to the student in a situation of teaching-learning. Nevertheless, taking into account this reference framework in a didactic process for optimal learning is desirable, even essential [26].

4 The representations of Moroccan learners about the concept of immunity

4.1 Towards a definition of the concept «representation»

The concept of representation has had a crucial place in the development of science didactics. It has a double psychological and epistemological anchorage [27]. These are intellectual constructs of children with explanatory role models in science learning situations.

What characterizes this definition is the dynamic character of representations. In fact, the knowing subject is an actor who builds his knowledge during his social history: he proceeds in a development activity of a new network of knowledge by confronting new information with his previous knowledge. In this sense, the subject's prior knowledge is crucial in a learning process as pointed out by Ausubel [28]: "If I had to reduce the entire psychology of learning to a single principle, I would formulate it as follows: the most important factor that can influence learning is the baggage of knowledge that the individual already possesses". In other words, the way in which the subject will interpret the surrounding reality and integrate new information into his mental structures will be largely determined by his pre-existing cognitive configurations.

However, it is very difficult to consider in isolation the different fundamental concepts of immunology that are organized in networks and interact in a dynamic way, and thus do not abide by a hierarchical structure. To get around this difficulty, we will choose "immunity" as a single key concept in immunology.

4.2 Methodological framework

In the context of this article, we have limited ourselves to presenting the representations made by some Moroccan students of the concept of immunity [29]:

- **Target population:** students in the 3rd year of middle school education.
- **Instrument for collecting student representations:** a combinatorial of situation-problems drawn from the daily life of students revolving around topics related to immunology (inflammation, vaccines, skin transplants, allergy and AIDS). These problem-situations have a certain degree of complementarity and overlap in order to allow the emergence of conceptual networks relating to the chosen immunological concepts. They also have a binding character inspired by moments of crisis that mark the historical development of immunology.
- **Data analysis:** identify the gap that exists between formal knowledge in immunology and the "already-there" of the respondent students concerning this knowledge according to a qualitative approach. The aim is to make a semantic division of the data corpus in order to establish certain facets (nuclei of meaning) of their representations concerning the notion of immunity by means of an evolutionary, flexible and self-generating meaning.
- **Analysis grid:** It is constructed from the historical scan of the conceptual field of immunology which revealed to us three major stages that marked the evolution of the concept of immunity. This is a stage where a clear definition of immunity does not appear in the theoretical reflections of the authors, it is the pre-Pasteurian stage where immunity is an obscure image that does not fall under any explicit formulation (**Category 1: the Pasteur model of the disease**). A second step where a definition of immunity begins to be established corresponds to a warlike defense against microbes (**Category 2: the military-warrior model**) and a third stage, where the emphasis is on recognition and immunity, becomes the ability to discriminate the self from the non-self (**Category 3: the cognitive model**).

4.3 Results and discussion

Without attempting a systematic and exhaustive examination of the various representations implemented by the students to solve problem-situations related to immunity, it is nevertheless possible to identify two major trends:

- A representation where a definition of immunity does not appear or corresponds to an obscure image;
- A warlike representation of immunity.
- We categorized the first tendency in the category "Pasteurian model of the disease" and the second tendency in the category "military-warrior model".

First category: The Pasteur model of the disease - In this category of representations, the organization represents itself as "*a passive, innocent and*

*disarmed entity*². It is "*perpetually attacked by the outside world with which it establishes a relationship of exteriority and confrontation*". The disease is of external origin, it is inherent to an exogenous factor endowed with all the characters of aggressiveness and malfaisance. This representation of the disease, assimilated exclusively to the exogenous one, gives it a particular image.

This representation of the disease is considered a maleficent corpus that transgresses a body, it is a kind of punishment that reaches the body. It is an ontological representation of a trouble that is confined to an entity whose only purpose is to cause the nuisance: the microbe. It is a kind of overvaluation of the microbe that finds its root in the daily life of the students.

Indeed, the microbe is a sufficiently pregnant construct that has fed the social imagination and framed a set of behaviors and regulations behind a phobia and an exaggerated fear of the disease. The importance of this construct means that a shift in meaning occurs between different entities, including allergens and toxins. They have one thing in common: that of causing harm. The overvaluation of the microbe is behind this extrapolation and this assimilation of toxins and allergens to microbes.

This omnipresence of the microbe as the ultimate cause of the disease conceals the ground of reception. The host, which is considered "*an innocent battle field, suffers the destructive action of a maleficent being: the microbe*." In this sense, the signs of inflammation, redness, pain, pus are the results of "*an alteration of the skin by the microbe*". Pus is a "*set of dead cells that have been destroyed by microbes*".

The signs of inflammation are designed negatively; they hardly represent a beneficial effect for the body. They are disparaged as they represent a source of embarrassment. The microbe, which proposes itself as a destructive being, acts in its entirety and not through a toxin.

As for the explanation of the manifestation of an asthma attack, it makes use of a model of linear causality: the allergen (grains of pollen) acts directly on the bronchioles of the lungs in the excitants and subsequently the latter contract. Students therefore reason in succession: the allergen enters the body and causes the asthma attack.

It is clear that no definition of immunity is included in the discourse of the students surveyed. Even if students talk about the immune system, immunodeficiency and immunity, these are terms that do not refer to any explicit definition.

Immunity is a fuzzy, obscure image, inherent in transcendental forces. However, it is accounted for as a kind of resistance to the disease whose essential factor is the microbe. Moreover, immunity has been made synonymous with health, good nutrition and sport; in short to the well-being and comfort of life.

In such a representation, the body is viewed in a negative way. It is a passive entity that is not endowed with a power of resistance. In this connection, the spontaneous cure of a microbial disease without the intervention of a physician is explained by references to nutritionist considerations that remind us of the Bernardine theses of the external environment.

² The wording in italics and quotes "... "is taken from the students' authentic responses to the various problem situations.

The microbe "which is exhausted by the disappearance of an essential nutrient element in its life, dies of hunger". Some explanations refer to "death due to an intra-specific struggle, a kind of cannibalism" or through a germ contamination. It is a mechanistic representation which limits the disease to the presence of the germ which does not multiply, the inoculation of another person can cure of the disease. It is a representation that advocates the guilt-tripping dimension on the disease, as a moralization of it.

The resistance to a second infection by the same microbe or toxin injection is interpreted in several ways but does not refer to a dynamic resistance of the body. Among these explanations, we find the "familiarization or the habit of the organism with these microbes or this toxin". This familiarization is not defined in a univocal way. It is a kind of extrapolation of human feelings and behaviors to explain a biological phenomenon.

These explanations are imbued with anthropomorphism to the extent that the student tends to maintain part of one self in a natural phenomenon: resistance to infection or toxin. These explanations refer to common social activities relating to human relations: familiarization and habit.

The familiarization model is used to explain the tolerance of a toxin, an allergen during desensitization tests or an auto transplant. It is an extrapolation of human feelings to explain a biological phenomenon.

Another representation is conveyed to explain the resistance or the tolerance of a second toxin injection, it is the homeopathic model which claims that evil heals evil; infinitesimal quantities of toxin or microbe can have an enormous healing power. This homeopathic representation has roots in the history of medicine; it is a therapy that comes from philosophy and ontology: evil heals evil.

In this representation of the organism-as a passive entity, unfit to fight and defend its integrity - healing, according to medical ideology sufficiently pregnant, comes from the doctor who helps the body to acquire its initial state of health and who has all the abilities to eradicate and purify the body thanks to his authority of knowledge and technique. It is at the price of this eradication that the body can reach its normal state which is symmetrical with the pathological state.

The doctor is able to do this purification by means of an antibiotic. This is a highly over-valued medicine. It destroys germs or eats them. It is a set of "cells" that eat and destroy microbes. This vitalizing representation of the antibiotic can have several origins that fit together:

- Evil heals evil (homeopathic representation);
- The fight on equal terms, the formulation of the term: anti and biotic, which means an anti-living, in the arabic language;
- The shift in meaning of a popular science media: antibiotics are extracted from microorganisms.

Moreover, this vitalist representation of the antibiotic can be behind several dysfunctions of which we can mention: an over-evaluation of the antibiotic which underlies an effectiveness of the latter in the fight against all the diseases, which are of bacterial and viral origins. The specificity of antibiotics to fight against certain

types of bacteria and the bacterial resistance to certain types of antibiotics are concepts ignored by respondents.

In the same vein, the vaccine is designed as a curative treatment that consists of protecting the passive and helpless body against microbial attacks. It represents itself as a "medicine", an "antibiotic", a "set of vitamins" and a "wall". Some students have reasoned in terms of serotherapy. For them, the vaccine is a set of "antibodies". In short, all these formulations give the vaccine a curative character, of immediate and transient effectiveness. It immediately diffuses into the circulation and acts quickly, hence the need for booster shots³.

However, although students are familiar with booster shots, they see their utility differently. The booster injections correspond either to "a means to test the effectiveness of the vaccine", or to "cope with very dangerous diseases" or they consist in "restoring the lost strength of the vaccine during the fight against the microbes of the diseases".

Second category: the military-warrior model - These representations draw their raw materials from the semantics of war. Indeed, students would be seduced by the semiology of combat and war that meets their needs for war games with all they include as virtues: heroism, adventure, sacrifice, revenge, ... etc. In this category of representations, the organism presents itself as a dynamic entity endowed with a power of resistance. In the face of a microbial aggression, the organism is not passive, it has a war arsenal that can defend its integrity and fight against the invaders. This arsenal is made up of white blood cells and antibodies.

In this sense, the spontaneous healing from influenza is explained by an "organism's fight against the influenza virus". This struggle is led either by the white blood cells or by the antibodies. As for inflammation, it is sometimes seen as a "defense process to fight germs", sometimes as "the result of a defeat of the effectors of immunity to invading microbes".

The swelling of the lymph nodes is explained by "a gathering of white blood cells to learn how to implement the defense strategy." The lymph node thus represents itself as a "barrack". The vaccine, which is prepared from attenuated microbes, is conceived as a preventive treatment that consists in stimulating the immunity of the body.

This attenuation consists either in extracting the genetic material from the microbe, the nucleus, or in reducing the dose of pathogenic microbes. Vaccination is thus a kind of "war fighting simulation that allows the effectors of immunity to fight against a possible microbial aggression".

As for the booster injections, they are administered so that the effectors of immunity, antibodies and white blood cells, can "memorize more the strategy of defense against microbes of the preventable diseases".

In this logic, resistance to a second infection with measles or whooping cough is explained by a memorization of the mode of defense during the first infection. This

³ The same representations were found among Tunisian students in the first year of secondary education. Allaya, H. (2012). Conception, argumentation et problématisation des élèves de la 1ère année secondaire en immunologie. Thèse pour l'obtention du grade de docteur de l'Université de Tunis et l'Université de Nantes.

resistance, through an immune memory, is not generalizable to all infectious diseases; the students presented the example of influenza and tonsillitis. The rejection of a heterograft is explained by an attack of the immune system. These are the white blood cells that support the defense against this foreign graft. The strangeness of the graft is translated by an "incompatibility of the blood groups between the donor and the recipient". The transfusion model is important in explaining the rejection and / or tolerance of a transplant.

Table 1. Categories of students' representations of the concept of immunity

Major trends in representations	No. of respondents
Category 1: the Pasteurian model of the disease	16/20
Category 2: the military-warrior model	4/20
Category 3: the cognitive model	0/20

5 Conclusion: towards the formulation of a reference framework for continuing training in SLE didactics: immunology as a model

What knowledge reference in didactics applied to the teaching-learning of immunology can we offer in a continuing training of middle school teachers?

It goes without saying that didactics applied to the teaching-learning of immunology could play an important role in initial and continuing training activities [30]. The knowledge thus developed is not intended to create a scientific didactics, but to provide a reference framework to enlighten the action of the teacher in the perspective of optimal learning in immunology for the Moroccan student. The teacher's proposed teaching should lead the student to conceive immunity as a complicated function provided by an immune system whose effectors interact together and try, at any given moment, to discriminate the self from the non self through the markers of individuality and to appropriate the profound changes that immunology has undergone in recent times [31].

With this in mind, the study of the content of student representations relating to immunity proves to be essential for the proposal of a knowledge reference in didactics applied to the teaching-learning of immunology in a continuous training of teachers in SLE of middle school education. It is legitimate to look for pre-scientific modes of reasoning in these representations that constitute obstacles that prevent the installation of a real need for learning: they respond in a consistent and viable way to students' questions and explanations. These barriers are dynamic, they are rarely isolated and, as a result, they interact together; which explains their resistance and their pregnancy [32].

The teacher must be equipped to create an appropriate learning environment [3] that can help to adequately build a learner's new knowledge network in line with the recent knowledge of immunology. Emphasis must be placed on the desire to design optimal, open-ended, meaningful and regulatory didactical immunological situations

calling for a process of research, identification and problem-situation resolution. Organizing and facilitating learning situations in immunology means having the necessary professional skills based on a reference didactic knowledge of SLE adapted to immunology defined by the following components:

- A historical-epistemological analysis of the conceptual development of immunology;
- A presentation of the status of immunology in the Moroccan programs of the SLE in the middle school and a brief overview of the difficulties inherent in the teaching thereof;
- Highlighting students' representations of the notion of immunity with a focus on those that represent obstacles that could hamper the conceptualization of immunology among Moroccan students.

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